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SOVIET STABILIZATION OF SHIFTING SANDS WITH BITUMEN EMULSION

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Sand stabilization and afforestation are important aspects of the Stalin Plan for the Transformation of Nature. Mechanical sheltering of crop and tree plantings is the usual method of controlling shifting sands. Disadvantages of this method are the great amounts of labor involved and the impossibility of mechanizing this type of work. The authors of this article and N. N. Banasevich (deceased), scientific workers of the Agrophysical Institute, have developed a more rational method of stabilizing sands by using a bitumen emulsion.

Bitumen is a residual product of oil processing and refining. Experiments conducted over many years have shown that bitumen, like natural oil, tar, and other materials, is capable of imparting a stable character to sand. But only bitumen has no harmful effect on young plants.

Laboratory experiments were carried out in the following manner. Wet soil or sand was placed into containers of varying size and then grass or legume seeds (wheat, oats, barley, timothy, peas) were planted in the containers. A quantity of bitumen, tar, or pitch sufficient to cement the surface well (200-800 grams per square meter) was poured on the soil or sand. The surface in other containers was not covered and these containers served as controls. The times when sprouts appeared and when withering set in, as well as the weights of green and dry plant mass, were recorded as the experiments proceeded.

The sprouts of all experimental seeds used easily broke through the bitumen layer, developed well, and produced greater green and dry matter masses than did those in the control containers. The sprouts of seeds under a layer of tar (shale, dry-distilled, gas-producing, and coal tars were used) remained in poor condition and produced only one third to one half as much plant mass as did those in the control containers; they also died very quickly. Even when very large doses of bitumen were applied, the cemented layer was never a hindrance to the appearance of sprouts.

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The question of in what form bitumen should be applied to the surface of sand was studied for a long time. As is known, bitumen is insoluble in water. Therefore, it cannot be applied in the form of an aqueous solution. It is also very difficult to keep bitumen in liquid condition. It is viscous enough to be applied evenly in small quantities over a large area only when it is at the boiling point.

Application of bitumen to a sand surface in the form of an aqueous emulsion is the most practical method. The most important advantage of a bitumen emulsion is the possibility of obtaining a desirable ratio of bitumen to water. Thus, an emulsion containing 5-10 percent bitumen can be spread evenly on the sand surface.

After a number of experiments, the authors, together with the Leningrad branch of the Highway Institute, set out to find an emulsion which would not lose its properties after frequent dilution with water and would not be dependent on the use of soft water.

Bitumen from Grade 1 Baku oil was used in preparing the emulsion. The temperature required for softening this bitumen was 30 degrees centigrade. Loss after 5 hours of heating at 165 degrees did not exceed one percent.

The bitumen was placed into an ordinary kettle and heated to a temperature of 160 degrees centigrade. In another kettle, water was heated to a temperature of 90-95 degrees centigrade. An emulsifier consisting of sulfite liquor and sodium hydroxide (10 kilograms of the former and 3 kilograms of the latter per ton of water) was added to the water. Bitumen and water were emptied from the kettles into a homogenizing machine. Pouring of bitumen and water into the machine was controlled by means of a special crane. The emulsion was then packed in barrels for transport to the place of application.

Before application to the sand, the emulsion is diluted in the proportion of one part of emulsion to 14 parts of water. Such dilution is necessary if the emulsion is to penetrate below the surface. After application of the emulsion, the upper layer of sand is cemented, to a greater or less degree, to a depth of 8-10 millimeters. Depending on the size of the area, the emulsion may be applied by hand spray pump, garden sprinkling can, or conventional fire engine. Tank trucks used for sprinkling streets could also be adapted to this purpose.

A question of great interest is the amount of bitumen required for effective cementation of the sand surface. The experiments of the authors have shown that generally one ton of bitumen is sufficient to treat one hectare of sand so as to prevent shifting and blowing of the sand, although somewhat more bitumen is necessary to stabilize the sands of upland windswept areas.

In the experiments, the stability of the bitumen surface was studied. It was determined that by increasing the amount of bitumen from 75 to 100 grams per square meter the stability of the bitumen surface was doubled. Further increases in the amount of bitumen used resulted in only negligible increases in the stability of the surface, although maximum stability was attained when 100-150 grams of bitumen were applied per square meter. Experiments showed that sand covered with bitumen withstands winds of 9 meters per second velocity. The experiments led to the conclusion that an amount not exceeding 100 grams of bitumen per square meter is the most expedient amount that should be applied.

Heating, permeability, and air penetrability of the bitumen surface were also studied over 6 years. Field experiments showed that after rains the water did not remain standing on nor did it run off the bitumen surface; thus, the bitumen-covered surface is adequately permeable for soaking up the water from normal rains. Experiments also showed that application of even 200 grams of bitumen per square meter did not prevent air from penetrating into the soil; this was shown to be true in both laboratory and field experiments. Field experiments showed no great difference between the diurnal temperature variation of uncovered sands and that of sands covered with bitumen. However, the diurnal temperature range became narrower under the bitumen-covered surface. For example, in experiments conducted at the Repetek Experimental Station of the All-Union Plant-Culture Institute (Turkmen SSR), the diurnal range on 21 May 1935, at a depth of 5 centimeters below the surface, was 14.1 degrees centigrade under the bitumen-covered surface and 18.2 degrees under the uncovered sand surface. During the warmest hours of hot summer days, the temperature was lower under the bitumen-covered surface than under the uncovered surface, while at night the temperature fell less rapidly under the bitumen than under the uncovered surface. In other words, the bitumen coating moderates temperatures in the sand and improves living conditions of desert plants.

Field experiments were begun in 1934 and continued until 1941.

The bitumen treatment was field tested in Chelkar, Kazakh SSR, Repetek, Turkmen SSR, and Tsyurupinsk, Ukrainian SSR in connection with various crops, on various areas, and by various methods. Results of experiments at the last two points are given below.

The Repetek station is located in the southeastern part of the Kara-Kum Desert. The climate there is typical of extratropical continental deserts. It is characterized by sharp variations in air temperature, great aridity, low cloudiness, and little precipitation which falls mostly in spring and winter. Annual average precipitation does not exceed 100 millimeters. Winds are frequent and often blow at velocities of 12-14 meters per second. The upper layers of soil are composed of fine sand with the proportion of coarse sand increasing with depth.

The authors chose this area with its harsh climatic conditions with the thought that, if their method proved to be successful there, it would also be successful in other areas.

The first experiments began in 1935. Alfalfa, sainfoin (Onobrychis), barley, and watermelons were sown; then all plots were covered with bitumen. All crops sprouted, easily broke through the bitumen cover, and developed well.

Eventually, experiments were carried out on areas up to 25 hectares in size. In December 1935, black saxaul seed was sown immediately after a rain on a half-hectare plot. Then, half of the area was covered with bitumen. By the spring of 1937, the experimental area had been increased to $2\frac{1}{2}$ hectares. In May 1937, the condition of the plants was examined. On the uncovered portion of the area, the wind had destroyed the plants. The condition of the plants on the portion of the area covered with bitumen is summarized in Table 1.

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Table 1. No of Black Saxaul Plants on the Area Covered With Bitumen

Location	No of Plants per Sq M	Ht of Plants (cm) Av	Max
Low places between dunes	340	5	9-12
Slopes of dunes	198	11	15-18
Crests of dunes	52	5	6-9

All subsequent experiments in Kara-Kum were carried out on a larger scale and other varieties of woody plants were tried. Various methods of spraying, as well as other methods of applying the bitumen emulsion, were tested. V L. Leont'yev, Candidate of Biological Sciences, took part in all experiments.

Parallel experiments were carried out in the Tsyurupinsk area, on the lower Dnepr sands. In 1938, an experimental plot 1.6 hectares in area was planted with willow. Half of this area was covered with bitumen at the rate of one ton per hectare. The other half was divided into two parts; one part was protected with a covering of reeds, the other remained uncovered as the control area. In the fall of 1940, that is, 2 years later, the results were tabulated as follows.

Table 2. Survival of Willow Under Various Covers

Experimental Variants	No of Plants	No of Surviving Plants	Survival Rate (%)	Av Ht of Main Stem (cm)	Av No of Branches per Bush
Bitumen cover	244	183	75	20.2	1.6
Reed cover	233	138	59.2	19.3	1.6
Control	137	54	39.4	17.3	1.4

This experimental area was completely destroyed during the German occupation, and so it is impossible to determine what the ultimate results of this experiment on the lower Dnepr sands might have been. But in 1946, the Agrophysical Institute detailed V. L. Leont'yev to make an examination of the experimental area in Repetek. He found that traces of the bitumen which had been applied 10 years earlier had been preserved and that the sands had been stabilized to some extent. Saxaul planted 8 years earlier had multiplied and become as tall as 3.5 meters where cattle had not grazed and averaged 1.5 meters in height where cattle had grazed. Thus, the results show that the experiment was a success.

The experiments showed that the bitumen cover not only was not harmful to seeds and plants but even improved the physical conditions of the sands somewhat. The authors are of the opinion that one or two sand-stabilization stations should further test this new method on a large scale.

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